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Computational Simulations of Laser-Initiated Stress Waves*

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We present a study of the short-timescale (less than 1000 ns) fluid dynamic response of water to a fiber-delivered laser pulse of variable energy and spatial profile. The energy study shows the models ability to handle both linear and non-linear hydrodynamics. The energy was varied as 0.1 through 1.0 mJ/pulse. The laser pulse was deposited on a stress confinement timescale. The spatial profile study shows how the stress wave varies as a function of incident geometries. For example, relatively small absorption coefficients can result is side-propagating shear and tensile fields. The spatial profile was determined by the fiber core radius, r, (110 and 500 microns) and the water absorption coefficient, mua, (1500, 500 and 50 1/cm). Considering 2D cylindrical symmetry, the combination of fiber radius and absorption coefficient parameters can be characterized as near planar (1/mua greater than r), symmetric (1/mua = r), and side-directed (1/mua less than r). The 2D model results were converted into refractive index maps and are compared with interferometric experimental measurements of the density field as a function of geometry and energy.

The 2D cylindrically symmetric simulations were performed with the computer model LATIS3D (LAser-TISsue). Coupled hydrodynamic and a custom water equation-of-state were used. The custom water equation-of-state is a high-resolution table incorporating phase changes. The hydrodynamics package uses a discontinuous finite element method with an unstructured mesh. Simulations were run with both Lagrangian and Eulerian hydrodynamics. The simulated geometry included a room-temperature, 1 atmosphere ambient water field with an optical fiber.

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